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Research Article

Influence of seed rate and NPK fertilizer on yield and quality of Rhodes grass (*Chloris gayana* L. kunth.)

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ABSTRACT
A field experiment was conducted during summer season of 2007 at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum, Shambat, Sudan, to investigate the effect of seed rate and NPK fertilization on yield and quality of Rhodes grass forage (*Chloris gayana* L. Kunth) cv. Finecut. The treatment consisted of three seed rates (SDR1, SDR2 and SDR3) namely 5, 10 and 15 kg/ha and three NPK fertilizer levels (F0, F1 and F2) namely 0, 120 and 240 kg/ha respectively. NPK fertilizer components were N17 P17 K17. The experiment was laid out in a Factorial CRBD with four replications. The results showed that seed rate significantly increased forage fresh and dry yield. NPK fertilization significantly increased forage fresh and dry yield. Neither seed rate nor NPK fertilization were significantly affected crude protein and fiber content of leaves and stems of Rhodes grass, but the increase in seed rate and fertilizer levels slightly increased crude protein and decreased fiber percentage. Seed rate ×NPK fertilization interaction showed significant effect on crude protein and crude fiber contents. The highest protein percentage obtained under SDR2 (10kg/ha) with highest NPK fertilization level F2 (240 kg/ha), and lowest value obtained under SDR1(5kg/ha) with NPK fertilization F1(120kg/ha) and SDR1(5kg/ha) under control of fertilizer treatment (F0). Regarding crude fiber, highest value obtained under SDR2(10 kg/ha) with NPK fertilization F1 (120kg/ha) and SDR3 (15 kg/ha) under control treatments of fertilization (F0).
Keywords: *Rhodes grass, seed rates, NPK fertilizer, yield, quality*

INTRODUCTION
Forage production is gaining more attention in the tropics and the subtropics; in both developed and developing countries. Many new species, varieties and cultivars of forage and pasture plants have been introduced from different areas and countries rich in forage and pasture plant to areas where they are scarce. In Sudan forage production is very important because the forage is the basic source of energy for the growth and maintenance of livestock and increase their products, also due to the fact that Sudan has a huge number of animals which is estimated by about 143 million heads (goats 63 million, sheep 42 million, cattle 35 million and camels 3 million) in 1998 (Mohammed, 2000).
Overgrazing on natural pasture, expanding of rainfed agriculture on range land and improper conservation measures of the grazing land lead to reduction of rangeland. Most of the animals in Sudan are greatly dependent on the natural vegetation as their major source of feed for maintenance and production. This attitude is clearly reflected on poor output and performance of animals resulting from poor quality of forages and the problems of over and under grazing.
The possible solution to support the natural pastures is to establish and develop the irrigated pastures and encourage the utilization of agricultural by-products and crop residues that are produced in huge amounts for animals feeding in the Sudan. The most important forage crops cultivated under irrigation in Sudan are alfalfa, Abusabien (sorghum forage), Clitoria, Lubia, Phillipsara, Sudan grass and other forage crops like Rhodes grass which is grown in small areas around Khartoum; because the crop is introduced recently and the farmers did not know the importance and cultural practices of the crop. The total forage yield in Sudan estimated by about 105.2 million ton of dry matter (Abuswar and Drag, 2002); the natural rangeland shares about 78 million ton and irrigated forage produces about 4 million ton only and the crop residues provide about 21.8 million ton annually. Rhodes grass (*Chloris gayana* L. Kunth) has been a popular perennial grass in the tropics and the subtropics of east and southern Africa, Australia and Central America. The crop originated in eastern and southern Africa, and it's valued for its ability to cover ground, tolerance for drought, light frost, soil salinity

and suitability to be grown in association with many tropical legumes. The crop usually varies in organic compounds, crude protein 4-13%, crude fiber 30-40 %, ether extract 0.8-1.5 %, nitrogen-free extract 42-48 % and digestibility is 40-60 % of dry matter. Therefore, the crop is highly palatable to animals. Valenzuela and Smith (2002), described the benefits and uses of Rhodes grass as, excellent for erosion control and weed suppression, well for quick growth, although establishment may be relatively slow. Rhodes grass is cross-pollinating (Skerman and Riveros, 1990). Number of chromosomes are 2n=20, 30, 40 (Fedorov, 1974). The diploids (2n=20) include cvs. Pioneer and Katambora and the tetraploids (2n=40) include cvs. Callide and Samfrod. Breeding and selection aims at plants that are leafier and late flowering. Partirdge, (2003) described that two new varieties have been selected from Katambora and Pioneer for hay production for the Middle East market was (Finecut) is derived from Katambora and (Topcut) from Pioneer. Luna *et al.* (2002) pointed that the diploid and tetraploid cultivars are available in the market; the latter are more productive but also less salt tolerant.

According to FAO (2003), there are some other African varieties namely Giant Rhodes; Mbarara from Uganda, Rongai is grown near Nakuru; Kenya, Nzoia, Pokot and Masaba are grown in Kenya and Karpedo is suited to the drier areas of Kenya. Mclove *et al.* (1982), stated that *Chloris gayana* was adapted to lands down soil but it was the outstanding grass at that site. Harwood *et al.* (1999) reported that Rhodes grasshad poor emergence (4-5.5%) onmoderate- very strongly alkaline/ medium- high salinity class tertiary spoil soils. Ortega *et al.* (2006), pointed that salinity have harmful effect on growth of Rhodes grass Seedling leaves and elongation on successive days, this is due to reduced hydraulic conductance in salt-stressed plants.Ehrlich *et al.* (2003) reported that Rhodes grass cultivars are not greatly harmed by pests and diseases. *Chloris gayana* can be used as fresh forage or in the form of silage,but utilization as hay and green forage is the major use. According to FAO, (2003) the crop makes quite good hay if cut just as it begins to flowering or a little earlier. Old stand give low quality hay. Silage has been made successfully in Nigeria, Zambia and Northern Australia, but generally it does not give satisfactory silage.In Zambia Rhodes grass alone yielded 58 DM ton/ha. Under irrigation in Texas, yield of dry matter is 15.775ton/ha was recorded. In South-West Australia a yield of 23.639 ton/ha was obtained from an irrigated Rhodes grass pasture treated with three dressings of fertilizer, each dressing providing 56, 22, 45 kg/ha of Nitrogen, Phosphorus and Potassium, respectively (FAO, 2003). Duke (1983), found that the dry matter yield was 15.5-17.2 MT/ha annually in Florida, U.S.A, and higher yields reported when planted in 25 cm rows and fertilized with 150 kg N/ha.Gherbin*et al.* (2007), showed that *Chloris gayana* yielded high dry matter in warm-season areas when grown with others species of grasses and showed values ranging from 16.4 to 21.1 ton/ha. Abudiek (1980) found that Rhodes grass resulted in the highest yield from mixture of grasses with butter fly pea and phillipesara in Sudan. Ehrlich *et al.* (2003) pointed that reducing the frequency and total volume of irrigation resulted in a reduced level of soil water and pasture yields of Rhodes grass.

Phosphorus plays an important role in photosynthesis processes to produce protein and remobilization of sugar to starch. On the other hand, phosphorus enhances reproductive growth, root growth and make stem strong to prevent plants lodging (Burhan and Hago, 2000). Grof (1980), reported that Rhodes grass was classified as medium phosphorus requirer. Crowder and Chheda (1982), and Mclover (1984), found that tiller and leaf number of Rhodes grass increased with increase in phosphorus rates, but the increase was much greater for tillers than leaves. Geweifel (1997), in Egypt found that application of phosphorus favoured the growth of sorghum plants as expressed in more height, leaf area, plant dry weight, leaf to stem ratio, number of tillers/m², and fresh and dry forage yields of sorghum. Regarding forage quality results indicated that crude protein % was significantly increased with phosphorus application up to 31kg P2O5/fed. Abbas (2003), and Gasim (2001), found that crude protein increase with phosphorus application. Abbas, (2003) showed that crude fiber decreased with addition of phosphorus. Plants need a large amount of potassium, however, potassium not enters in composition of organic matter, but it plays an important role in physiological processes of plant. (Burhan and Hago, 2000).Wilkinson and Langdale (1976), showed that a spilt application of nitrogen is superior to large single application in producing yield of warm season grasses. Henzell (1971), reported that nitrogen fertilization caused a significant increase in the nitrogen content of soil, roots and dry matter of Rhodes grass. Cowan *et al.* (1995) stated that the increases in pasture yield of Rhodes grass are at a maximum when nitrogen applied to pastures. Saeed (1988), found that dry matter production of pre harvest samples and final harvest increased significantly under higher levels of nitrogen in fodder sorghum. Similar result was stated by (Adam, 2004; Elawad, 2004; Gasim, 2001; Skerman, 1990; Soliman, 2005; and Sawi, 1993).Wilkinson and Langdale (1976), reported that large quantities of potassium are required to replace K removed in harvested forage and to offset potential leaching losses because of the greater mobility of potassium. FAO (2003), stated that Rhodes grass early gives a response to potash in some area in the presence of nitrogen and phosphorus. Smith (1974), pointed that the amount of potassium required to achieve maximum growth was progressively reduced as the level of sodium application was increased in Rhodes grass grown in relatively high saline soils. Potassium application did not affect shoot dry matter (SDM) in soils having maximum clay content because this soil is rich in available K and have more potassium fixing capacity (Abdulwakeel, 2005).

MATERIAL AND METHODS

The study was carried out at the Demonstration Farm of Faculty of Agriculture, University of Khartoum; Shambat, Sudan during the summer season of 2007. The objective of the study was to investigate the effect of seed rate and NPK fertilization on yield and quality of Rhodes grass forage (*Chloris gayana* L. Kunth) cv. Finecut. The soil is a typical clay soil of the Central Clay Plain. (Saeed, 1988) described this soil as deep cracking moderately alkaline clays with pH 7.5-8. The experiment comprised of nine treatments which include three seed rates (5, 10 and 15 Kg/ha) of Rhodes grass cultivar Fine cut and three levels of NPK fertilizer levels namely (0,120 and 240Kg/ha). Experimental design used was a factorial with CRBD with four replications. The experimental area was disc ploughed, followed by disc harrowing to crush clods and then levelled. Ridging was done after levelling. The size of individual plot was (4×5 meters). Each plot consisted of five ridges, five meter in length and 70 cm apart. The field was irrigated before sowing to crush clods to ensure a fine seed bed. The seed was sown broadcasting using three seed rate in row done by hand about one centimetre deep on the middle of the ridge. The sowing date was 8th of April, 2007. After sowing the field was uniformly irrigated to ensure optimum germination and uniform crop establishment. After germination the crop was irrigated every ten days interval. NPK fertilizer was applied on the growing side of the ridges in lines after 21 days from sowing date in one dose at the three treatment levels (control F0 0kg/ha, F1 120kg/ha and F2 240 kg/ha). The parameters measured were leaf to stem ratio, forage fresh weights and forage dry weights ton per hectare, the data was collected at 30, 60 and 70 (at harvest) Day after sowing (DAS). In addition to that proximate analysis was performed on the dry weight samples to estimate forage quality in form of crude protein and crude fiber according to A.O.A.C. (1995) in the final harvest when the samples from forage dry yield were oven dried and grinded. The data were statistically analyzed using SAS statistical analysis software package, as a factorial design, by the Standard Analysis of Variance Techniques (Gomez and Gomez, 1984). Means separation was performed by Duncan's Multiple Range Test (DMRT) procedure.

RESULTS AND DISCUSSION

Leaf- to stem ratio:

The results showed that seed rate and NPK fertilizer were not significantly affecting leaf- to stem ratio (Table 1). NPK fertilization × seed rate interaction for leaf-to stem ratio was also not significant at the first sampling, but the second one showed significant effect as shown in Table 2.The highest leaf-to stem ratio obtained at second seed rate SDR2 and second fertilizer level F1.

Forage yield

Forage fresh weight (ton/ha):

The effect of seed rate and NPK fertilization on forage fresh yield is shown in Table 3. During all sampling occasions there was no significant difference in forage fresh yield between the different levels of seed rate, except at the second sampling occasion, where there was a significant effect at age of two months.

Table 1 The effect of seed rate and NPK fertilization on leaf -to stem ratio of Rhodes grass at different sampling occasions during 2006/2007

Sampling occasions	1stSampling (30DAS)	2ndSampling (60 DAS)
Seed rate Treatments ➘		
SDR1	11.643a	2.3775a
SDR2	10.873a	2.5892a
SDR3	10.795a	2.535a
NPK fertilizer Treatments ➘		
F0	11.941a	2.5075a
F1	13.028a	2.6358a
F2	8.342a	2.3583a
Means	11.1	2.5
C.V%	35.5	15.7

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT

Table 2 Seed rate × NPK fertilization interaction for leaf-to stem ratio at age of 30 and 60 days during 2006/2007

NPK fertilizer Treatments➥	F0	F1	F2
Seed rate Treatments ➘	1st sampling occasion (60 DAS)		
SDR1	12.11a	15.4a	7.43a
SDR2	12.04a	12.41a	8.17a
SDR3	11.68a	11.28a	9.44a
2nd sampling occasion (60 DAS)			
SDR1	2.518ab	2.423ab	2.193b
SDR2	2.503ab	2.81a	2.46ab
SDR3	2.503ab	2.68ab	2.423ab

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT

The effect of NPK fertilization on forage fresh yield was significant at all sampling occasion, except the last sampling at harvest. Seed rate × NPK fertilization interaction for forage fresh weight was significant at all cuts, except the last one (Table 5).

Forage dry weight (ton/ha):

As shown in Table 4, forage dry yield of Rhodes grass was not significantly influenced by seed rate, except the second sampling occasion which was significant at age of 60 days. However, NPK fertilization significantly influenced forage dry weight at the second sampling occasion. It was observed that dry forage yield increased with the increase in NPK fertilization level. The result also indicated that dry matter yield increased with increase in seed rate, except the last sampling occasion. Seed rate × NPK fertilization interaction for forage dry yield was significant at first and second sampling occasions as shown in Table 6. The highest forage dry yield was obtained at higher seed rate (SDR3) with higher level of NPK fertilization (F2).

Table 3 The effect of seed rate and NPK fertilization on forage fresh yield (ton/ha) of Rhodes grass at different sampling occasions during 2006/2007

Sampling occasions	1st sampling (30 DAS)	2nd sampling (60 DAS)	3rd sampling At harv.70 DAS
Seed rate Treatments➘			
SDR1	6.731a	24.648b	36.997a
SDR2	6.874a	30.17a	32.97a
SDR3	8.445a	30.32a	36.826a
NPK fertilizer Treatments			
F0	6.198b	24.733b	32.757a
F1	7.279ab	27.458b	35.144a
F2	8.574a	32.95a	38.892a
Means	7.34997	28.3805	35.5975
C.V%	36.4	19.9	26.7

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT

Forage quality:

Crude protein per cent:

The effect of seed rate and NPK fertilization on crude protein content of leaf and stem is presented in Table 7. The effect of seed rate on crude protein was not significant at (P>0.05). There is slight increase in crude protein however, with increasing seed rate. Seed rate SDR3 produced higher crude protein than SDR2 and SDR1. Regarding NPK fertilization also had no effect on crude protein. The lowest crude protein was recorded under the control treatment (F0), and the highest crude protein scored under high NPK fertilization level (F2).Seed rate × NPK interaction for protein content was significant (Table 8). The highest value of protein content was obtained at the seed rate (SDR2) 10 kg/ha under the highest NPK fertilization level (F2) 240kg/ha, while the lowest value was obtained at seed rate (SDR1) 5 kg/ha under (F1) NPK fertilization level (120 kg/ha).

Table 4 The effect of seed rate and NPK fertilization on forage dry yield (ton/ha) of Rhodes grass at different sampling occasions during 2006/2007

Sampling occasions	1st sampling (30 DAS)	2nd sampling (60 DAS)	3rd sampling At harv. 70 DAS
Seed rate Treatments ➘			
SDR1	1.1143a	6.5882b	10.386a
SDR2	1.1167a	7.9191ab	9.457a
SDR3	1.4644a	8.3286a	9.971a
NPK fertilizer Treatments ➘			
F0	1.1024a	6.8572b	9.481a
F1	1.1928a	7.25b	10.029a
F2	1.4001a	8.7287a	10.305a
Means	1.23	7.61	9.94
C.V%	36.0	21.15	26.55

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT.

Table 5 Seed rate × NPK fertilization interaction for forage fresh weight at age of 30, 60 and 70 days (at harvest) during 2006/2007

NPK fertilizer Treatments ➥	F0	F1	F2
Seed rate Treatments ➘	1st sampling occasion (30 DAS)		
SDR1	4.6858b	7.7713ab	7.7358ab
SDR2	7.1928b	7.0288b	6.4003b
SDR3	6.7143b	7.0355b	11.586a
	2nd sampling occasion (60 DAS)		
SDR1	22.6420c	24.9153c	26.3863c
SDR2	25.4718c	29.623abc	35.4158ab
SDR3	26.0858c	27.836bc	37.0488a

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT.

Crude fiber per cent:

The influence of seed rate and NPK fertilization on leaf and stem crude fiber content of Rhodes grass is presented in Table 7. The data showed that neither seed rate nor NPK fertilization affected leaves and stem crude fiber content of Rhodes grass. The lowest crude fiber was recorded under the second seed rate (SDR2), while the highest was obtained under (SDR3).Seed rate × NPK fertilization interaction for crude fiber was significant (Table 8). The highest crude fiber was obtained at SDR2 and F2. While the lowest one was recorded at SDR2 under control treatment (F0).

Table 6 Seed rate × NPK fertilization interaction for forage dry weight at age of 30, 60 and 70 days (at harvest) during 2006/2007.

NPK fertilizer Treatments ➥	F0	F1	F2
Seed rate Treatments ➘	1st sampling occasion (30 DAS)		
SDR1	0.8785b	1.229b	1.2358b
SDR2	1.2b	1.1143b	1.0358b
SDR3	1.2288b	1.2358b	1.9288a
	2nd sampling occasion (60 DAS)		
SDR1	5.9785c	6.393c	7.393bc
SDR2	6.9073bc	7.857abc	8.993ab
SDR3	7.6858abc	7.5abc	9.8a

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT.

Table 7 The effect of seed rate and NPK fertilization on crude protein and crude fiber content of *Chloris gayana* at harvest 70 DAS during 2006/2007.

Parameters	Crude protein %	Crude fiber %
Seed rate Treatments➘		
SDR1	7.543a	30.718a
SDR2	8.765a	30.516a
SDR3	8.787a	30.808a
NPK fertilizer Treatments➘		
F0	7.9a	29.88a
F1	8.15a	31.346a
F2	9.05a	30.815a
Means	8.37	30.68
C.V%	17.4	9.4

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT.

Table 8 Seed rate × NPK fertilization interaction for crude protein and crude fibre at harvest during 2006/2007

At harvest (70 DAS)			
NPK fertilizer Treatments➥	F0	F1	F2
Seed rate Treatments ➘	Crude protein %		
SDR1	6.69cd	6.4d	9.28a
SDR2	7.48cd	8.82ab	9.99a
SDR3	9.28a	9.21a	7.87bc
	Crude fiber %		
SDR1	30. 84ab	30.46b	30.85ab
SDR2	26.62c	31.82ab	33.11a
SDR3	32.19a	31.75ab	27.49c

Means followed by the same letter(s) are not significantly different at (0.05) level of probability according to DMRT.

Leaf- to stem ratio

Leaf- to stem ratio neither affected by seed rate nor NPK fertilization as seen in the results. This observation is in accordance with those obtained by Gasim (2001) who reported that the increase in seed rate decrease leaf stem ratio. This due to the fact that high seed rate produce high plant population, this lead to competition between plants for nutrients, moisture and light which resulted in thin stem and narrow leaves for plants of high seed rate, therefore, leaf- to stem ratio was reduced. Regarding effect of the fertilizer on leaf to stem ratio, no significant effect showed, but there is slightly increase in leaf to stem ratio with increasing fertilization level in late stage of growth (second sampling). This could be due to the positive effect of the fertilization on growth of plants. As stated by Gasim (2001), the increscent in N fertilization led to increase in leaf to stem ratio. Geweifel (1997) also found that application of P favoured the growth of sorghum plants and produced more leaf to stem ratio.

Forage yield

The results revealed that higher seed rate increased forage fresh and dry yields of Rhodes grass compared to lower seed rate. The explanation of this result in the fact that high seed rate resulted in high number of plants per unit area therefore, high yield. This finding is in line with that reported by Koul (1997) who stated that forage fresh and dry yield were substantially increased under the highest seed rates. Also this result is in conformity with the finding of other investigators (Abusuwar, 1997; Adam, 2004; Gasim, 2001; Nour, 2004 and Luca *et al*, 2001).

It was also found that the increase in NPK fertilizer level resulted in high forage yield (fresh and dry forage yield) compared to the control. This is attributed to the fact that nitrogen increases the photosynthetic capacity of growing plants, which enhances growth to produce adequate dry matter. It is observed from the results of growth attributes, the fertilizer increased number of leaves per plant, plant fresh and dry weight, and leaf area index. Consequently higher yield could be expected at higher NPK fertilization level. This finding is in agreement with the finding of several research workers about the effect of nitrogen and phosphorus on yield of different forage grasses (Cowan *et al*, 1995; Koul, 1997; Seaed, 1988; Skerman and Riveros, 1990; Soliman, 2005; Sawi, 1993; Geweifel, 1997; Mohammed, 1990; Buerkert*et al*, 2001 and Abbas, 2003).

Forage quality:

In this work forage quality was determined in term of crude protein content and crude fiber of whole plant (leaves and stems).Increasing NPK fertilization led to slight increase in crude protein percentage. This result emphasized the fact that nitrogen plays a great role in synthesis of protein. Also phosphorus plays an important role in photosynthesis processes to produce protein and remobilization of sugar to starch. Similar

results regarding the increased crude protein due to fertilizer application were obtained by several researchers. Kaftas, (1990) reported that nitrogen fertilization increased the crude protein of Rhodes grass by about 15% at the early stage of growth, but the percentage reduced at advanced growth stage (advance in maturity). Also Adam, (2004) observed that nitrogen improved forage quality by increasing crude protein of teff grass. Other similar results were obtained by Eltelib, (2004); Gasim, (2001); Koul, (1997) and Soliman, (2005). Moreover, Abbas, (2003) and Gasim, (2001) found that crude protein increased with phosphorus application. With regard to the effect of seed rate on crude protein percentage, was found not significant, but there was very small increase in crude protein with increasing seed rate. This result is in accordance with those reported by Adam, (2004) who summarized that increase in protein percentage of teff grass was observed as seed rate increased. Similar result was reported by Gasim, (2001) when he analysed the quality of forage maize.

Crude fiber was not significantly affected by either seed rate or NPK fertilizer. The crude fiber has relatively constant value at different seed rate of Rhodes grass, but the fertilization level F1 resulted in the highest crude fiber content than F2. This result is in agreement with finding of Gasim, (2001) who reported that increase in N levels reduced fiber content of maize forage. Adam, (2004); Abbas, (2003); and Koul, (1997) reported similar results on effect of nitrogen. And Abbas, (2003) showed that crude fiber decreased with addition of phosphorus. Similar result is reported by Abusuwar (2005).

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